

***Connecting Children to the Environment through Place-Based Education
and Community Involvement in Fredericksburg, Virginia***



By
Kinsley Greenlaw
Department of Environmental Science
Allegheny College
Meadville, Pennsylvania

March 2023

*Connecting Children to the Environment through Place-Based Education and Community
Involvement in Fredericksburg, Virginia*



By
Kinsley Greenlaw
Department of Environmental Science
Allegheny College
Meadville, Pennsylvania

March 2023

**Submitted in fulfillment of the senior thesis requirements of the
Department of Environmental Science and Sustainability at Allegheny College
and approved by the senior thesis committee.**

Prof. Kelly Pearce

Date

Wendy Kedzierski

Date

Pledge

Acknowledgments

I would like to thank Professor Kelly Pearce and my Creek Connections boss Wendy Kedzierski for all of their help and support throughout this project. Wendy especially saw me as the ES major I eventually would be when she hired me even though I originally didn't want to go into environmental education.

Thank you to Vicky Balboa, Joanna Houston, Becca Winton, Hailey Stupey, and Eva Kerr -as I spent most of my comping hours with these people on and off (an additional thank you to Heather for our little French Creek walks). I do not know how I would've been able to get through this project without our little dances we would create during breaks and the To-Do lists we drew on the boards. Thank you to the people (and dog) that accepted me as their sixth roommate and provided me with a comfort room, a place to work, and a group of people to watch through entire seasons of TV series while comping.

An additional thank you to all of the professors that I have had at Allegheny that supported me throughout my four years here. I have changed a lot these years but one of the constants in my college experience was the amazing professors I had across all of the departments I found myself in.

Abstract.....	
II	
Introduction.....	1
Formal and Informal Education Experiences.....	4
Env Education.....	5
Rappahannock River and Fredericksburg.....	6
Education and Advocacy by the Friends of the Rappahannock	7
Educational Materials for FOR.....	9
Activity Structure.....	10
Conclusion.....	12
Appendix I : Macroinvertebrates	
13	
Appendix II : Formation of Rivers	
18	
Appendix III: Rappahannock River	22
Appendix IV: River Otters in the Rappahannock.....	24
Appendix V : Leave No Trace (LNT).....	
28	
Appendix VI: Nature Journaling Activity.....	31
Appendix VII: Rappahannock River Food Chain.....	33
Works Cited.....	37

Name: *Kinsley Greenlaw*

Date: Spring, 2023

Major: Environmental Science

Thesis Committee: *Professor Kelly Pearce, Wendy Kedzierski*

Title: *Connecting Children to the Environment through Place-Based Education and Community Involvement in Fredericksburg, Virginia*

One of the things that are falling away with the digital world is our connection to the world around us. There is a need for change because the world is reaching the tipping point on whether or not we can reverse human-facilitated climate change. One of the ways that this change can be facilitated is by providing an avenue for adults to care for and feel the need to make positive environmental decisions. With environmental education during childhood that emphasizes centering their experiences along with a focus on place-based education, a connection can be drawn. When a connection to the environment is made during adolescence these values persist into adulthood. For this project, I partnered with the Friends of the Rappahannock (FOR) to work in the Rappahannock River located in the city of Fredericksburg, Virginia. FOR is a non-profit organization that works towards river advocacy, education, and restoration within and around the Rappahannock River. They have secured funding from the National Ocean and Atmosphere Association to help aid in applying the essentials of the Meaningful Watershed Educational Experience. The essentials focus on connecting children to their local environment and community. I created a curriculum with the intention to draw this connection and help satisfy the essentials of the Meaningful Watershed Educational Experience. With this curriculum students in the Fredericksburg City Schools will be able to have a place-based education curriculum that will foster connections to the environment and the community around them. From this connection, care for the environment during a crucial environmental crisis will be drawn so that they will be able to be environmentally conscious adults.

Introduction

A person's environment consists of the people and places around them. Someone's environment could be represented by the community or the natural world that surrounds the individual. Merriam-Webster defines nature as,

(1) the circumstances, objects, or conditions by which one is surrounded, (2a) the complex of physical, chemical, and biotic factors (such as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival, or (2b) the aggregate of social and cultural conditions that influence the life of an individual or community ("environment", 2022)

Nature, definition 2a, is what is commonly associated with the word environment is being threatened by human actions. From the start of the industrial revolution, humans have changed the world around us to a world unlike anything seen before. We are emitting more harmful gases into the atmosphere year by year and forever changing the Earth we live in. Between 2000 and 2010 total emissions from humans increased by 2.2 percent each year (Armstrong, 2018). Emissions are not the only environmental impacts that we need to worry about. One of the pollutants in our waterways is agricultural runoff from farms. Farming practices that are linked to pollution include pesticides and fertilizers entering the waterways from agricultural runoff (Environmental Protection Agency [EPA], 2005). As we increasingly become more of an industrial society driven by capital there will need to be added considerations for the natural world around us. One of the ways to combat this is by having sustainable farming practices and utilizing local produce and farmers as opposed to industrial agriculture. The second definition of the environment relates to the community surrounding an individual. These communities impact the way that people grow up and the values they carry into adulthood. Our decisions don't only impact the natural environment around us, but the community we surround ourselves with.

A way to spark a change in decision-making with respect to the environment and community is education. One of the main facilitators of change is education especially when it relates to morality and informed decision-making. Knowing about the environment allows people to care enough to change their attitudes. This change in attitude is more effective when there are outdoor educational experiences in childhood. When kids have a connection with the environment, they have greater care for it after adulthood (Chawla & Cushing, 2007; Mayer,

2008). There is a direct correlation between interactions between the environment and children in positive environmental attitudes in adulthood (Acar, 2014; Wells, 2006). Children before the age of 11 showed a stronger correlation between outdoor experiences leading to positive environmental attitudes (Wells, 2006). Positive environmental attitudes would include small personal decisions that are made with ecological well-being in mind. Some of these may include shorter showers, recycling, choosing sustainable products when able, or attempting to decrease their carbon footprint. One of the goals of environmental education is to provide an experience that allows for a change in environmental attitudes. Outdoor experiences that are place-centered and outdoor experiential learning foster a better connection to the environment (Otto, 2017; Cheeseman, 2018). By centering the children's lives the connection to nature is more likely to occur. In practice, centering a child's life means that they have more of a role in the educational relationship. Such as utilizing their previous experiences, allowing them to relate to previous memories, or allowing them to guide certain aspects of the conversation/topic. This connection allows the children to feel like they are attached to the environment that is being harmed by environmentally unconscious actions and attitudes (Mayer, 2004). Being connected to the environment and community around them will allow them to find a part of themselves to connect with the world around them. Through this connection, they will better be able to see the impacts that their actions will have on the natural world. This will also facilitate a connection to the community around the children because they will feel a sense of how their actions can impact the people around them as well.

In Fredericksburg, Virginia there is an organization called the Friends of the Rappahannock working towards the education, restoration, and advocacy of the Rappahannock River. Fredericksburg is nestled within the Patawomeck and the Manahoac tribes' historical territory (Native Land Digital, 2022). The Patawomeck (pronounced *Pahtohwomehk*) tribe didn't make contact with the Europeans on paper until 1559 and 1561 when they picked up a young Native American to convert to Christianity (Phelps, 2019). This first encounter was the beginning of a trend where the Europeans started to send missionaries for the sole purpose of converting the natives. In the later 1500s and early 1600s, there were increasing tensions between the groups. As Europeans began to ship more people to their territories the natives believed that they were just visiting and were suspicious when they began to settle. Between periods of starvation, unwillingness to accept gifts from the natives, and continuing westward

expansion there was a war declared and they shrank in numbers (Rountree, 1996). The second tribe, the Manahoac tribe, inhabited the Rappahannock river area before settlement and wasn't contacted until 1608 by John Smith. (Bushnell, 1935). Unlike the Patawomeck Tribe, the Manahoac were quicker to try and resist the white settlers. The tribe was pushed away and into other tribes where they had to disperse. The documentation of their settlements was not extensive so a lot of information is found in the pottery, arrowheads, and other scattered artifacts (Bushnell, 1935). However, by the town of Fredericksburg's establishment in 1728 the tribes had been removed. Due to its long history, the city has a lot of historical ties to the Revolutionary and Civil Wars (History of Fredericksburg, n.d). Fredericksburg was a highly sought-after land and was important in these wars because of the Rappahannock's importance to travel and commerce at the time. From the long history of the town, there is a large amount of care for the river and the city that was built next to it. There are large festivals and a heavy recreational community surrounding the river. The river had importance ecologically as a diverse ecosystem supporting organisms ranging from mussels (*Alasmidonta marginata*) (Jones, 2015), oysters (*Crassostrea virginica*) (Moore & Forget, n.d.), Northern river otters (*Lontra canadensis*) (Virginia Department of Wildlife Resources, 2023), as well as native and nonnative fish (native- *Morone saxatilis*, nonnative Blue Catfish - *Ictalurus furcatus* (Smithsonian Environmental Research Center, n.d.) The Rappahannock river flows into the Chesapeake Bay where there are a greater diversity of organisms. One of the main species that reside in the Chesapeake Bay is the Chesapeake Bay Blue Crab (*Callinectes sapidus*) (National Oceanic and Atmospheric Administration, 2023) which is important for a lot of people in Virginia and Maryland. The town cares a lot about the people who live there along with the natural world surrounding Fredericksburg because of the town's long history and love for the recreational activities in and along the river. With the increasing negative environmental impacts in the Rappahannock river, Virginia, The United States, and globally, there is a greater need for connection and care for the environment.

In Fredericksburg, I aided the non-profit group Friends of the Rappahannock to help educate the children about the natural world around the Rappahannock River and work to connect them with the people as well. The foundational essentials of the Meaningful Watershed Educational Experience will help aid in connecting the children with the Fredericksburg environments. The essentials will help emphasize the connection to the environment and

community through place-based education. There are four official essentials of the MWEE and they are Issue Definition, Outdoor Field Experiences, Synthesis and Conclusions, and Environmental Action Projects. These help provide a well-rounded environmental education curriculum. Another word to describe the essentials would be elements because although the four essentials are found within all of the lessons they are better described as a guideline that MWEEs follow. The guidelines in practice reinforce the idea that the lessons or activities will be learner-centered and focus on the students creating meaning from their experiences (National Oceanic and Atmospheric Administration, 2022) With the help from the Friends of the Rappahannock and the Meaningful Watershed Educational Experience, I created activities that focused on connecting the kids to the world around them and the community they live in. The activities are structured so that they can be taught in multiple different ways and focused on student-led education rather than centering the teacher's experiences. From this connection, they will be better prepared to make informed decisions about their lives and actions that will reflect positive environmental attitudes.

Formal and Informal Education Experiences

There are two different types of learning along with many different spaces to learn within the compulsory school system in primary and secondary school. The first type of learning space is the formal method of learning where students sit in classrooms and are lectured by a teacher. Typically this method is lecture-based or teacher-led and focuses on preparing students for an assessment or an evaluation. This method is within the classrooms and is compulsory and focused on empirically measured outcomes (Hofstein, 1996) The teachers in a formal learning environment are more focused on teaching facts and concepts. Students are expected to copy the correct answer that is given by the teacher. The dynamic doesn't allow for creative thought and a lack of involvement from the students (Coll, 2019). Teaching from a curriculum where students are meant to listen and copy the teacher's lectures do not allow the students to find a connection to their own experiences. The lack of student involvement is necessary for empirically measurable assessments or evaluations. While this method of learning allows for comparison across a large population of students, it is not focused on teaching lifelong morals or values (Coll, 2019; Hofstein, 1996). The second method of learning is informal education outside of the compulsory school classroom focused on lectures. One of the main ways that informal learning

occurs is through field trips and other optional learning spaces or activities (Coll, 2019). Informal education is typically voluntary, unstructured, and learner-centered, along with the fact that it is non-curriculum based. These learning experiences have less empirically measurable outcomes and are more focused on the student's experiences rather than the curriculum that is following a lecture plan (Hofstein, 1996). There is a large emphasis on formal education statewide because of the empirical results that are obtained. However, most of the children's time and learning is spent outside of the classroom about 85% (Medrich et al., 1982). If most of the children's time learning is spent in informal learning experiences then that is the space where their morals and values are formed. In informal learning, there is typically a variety of methods by that information is presented. Not only are there the more typical forms through learning centers or museums but there are also ways to have informal learning experiences within the classroom. One of these methods is having guest speakers attend a classroom session (Coll, 2019). There are multiple different speeds and methods of learning because in informal education there is no specific timeline or test at the end. It is a process-oriented method of learning that is emphasizing a partnership between educator and student (Coll, 2019). This difference in the informal and formal education methods allows for one of the more important distinctions that cause the 85% statistic on which spaces they learn in (Medrich et al., 1982). The important distinction between the two methods of learning is the learning dynamic between the student and the teacher. In an environment where a partnership is emphasized students will be more likely to participate and draw a connection to their personal experiences. By finding a relation to their own life experiences and way of viewing the world, they will have a way to find and relate to the environment. From centering the student's experiences and lives they will harbor a deeper understanding and connection to the world around them as they learn and grow (Sellmann & Bogner, 2013)

Environmental Education

Between the two of these forms of learning, there is a difference in how the information is presented and these lead to differences in the ways that information is retained in the children. When it comes to environmental education, the information must be presented in a way that leads to lifelong environmental attitude changes. Education through childhood is important but if it doesn't lead to pro-environmental attitudes in adulthood it will not be effective. One of the

important ways to facilitate positive environmental attitudes that persist into adulthood is a connection with the environment. Childhood experiences in nature are one of the main factors in shaping an adult's environmental attitudes (Chawla & Cushing, 2007). Positive interactions with educators and connection to the environment during childhood are what allow children to take an interest later in life. This interest will lead to the development of values that point towards environmental protection (Chawla & Cushing, 2007).

When determining how to structure lesson plans and activities the consideration of how the lessons will facilitate a connection to the environment is important. One of the things that need to be considered is allowing the children to feel a sense of competence with the environment. Disempowerment is one of the problems when it comes to environmental education because it leads to a feeling of doom and an inability to make a change (Chawla & Cushing, 2007). When educators are empowering the students that they are teaching they will feel competent in their ability to make life decisions that will positively affect the planet. When it is a community of people feeling competent then it will lead to collective competence leading to collective action (Chawla & Cushing, 2007).

Rappahannock River and Fredericksburg

There are 100 estuaries in the United States and the Chesapeake Bay is the largest. The bay has 6 states draining into the waters and thousands of rivers (Where is, 2022). From the number of people living in the bay drainage area, there are multiple complex threats to the ecosystem. Some of the threats include agricultural runoff, the growing dead zone, and development (Learn the Issues, n.d). These threats are increasing in severity and the need to work towards advocacy and education of the bay is of growing importance. The growing dead zone is a result of both eutrophication and conditions exacerbated by climate change. Eutrophication is the process of adding nutrients to a waterway increasing the vegetation. Runoff includes looking at both the land cover surrounding the Chesapeake Bay as well as the land use (Roberts, 2010). Land cover (LC) and Land use (LU) are connected to the urbanization of Fredericksburg and the surrounding areas. Land cover and land use refer to the ways that humans alter the environment around them. Examples of LC would be suburban areas, retail spaces, and parking lots while LU would be the conversion of land into agriculture, marsh draining, and channelization. A large portion of the cities that drain into the Chesapeake Bay are heavily

urbanized cities and are constantly expanding further with smaller towns, new roads, and new suburban development. The urbanization of these states contributes to additional issues from runoff including sedimentation, turbidity, and eutrophication (Roberts, 2010). One of the prevalent LU effects on Fredericksburg is the runoff of the nutrients phosphates and nitrogen from the farming that occurs around the town. One of the large threats to the Rappahannock River is oil and gas extraction. One of the main environmental impacts of oil and gas extraction is the contamination of the local waterways (Friends of the Rappahannock, n.d). Other threats to the water quality of the Rappahannock include storm runoff from local urban development, nitrogen and phosphorus, and land clearing from urban development as well (Irby, 2019). With these threats, there is a potential for the Rappahannock river to lose one of its best features, the quality of the water and the biodiversity within it.

The ecology of the river makes it a place that is heavily used recreationally for fishing and the overall health of the river allows for a lot of swimming and water activities. The section of the river that I focused on is the section that flows through Fredericksburg City. I focused on this section of the river because it is the stretch of river that the Friends of the Rappahannock advocates for.

Education and Advocacy by the Friends of the Rappahannock

The Friends of the Rappahannock (FOR) is a non-profit organization working towards the advocacy, education, and restoration of the river. The group was instrumental in the removal of the Embrey Dam in 2004 making the Rappahannock river the longest free-flowing river in the east at 170 miles (Rappahannock River, n.d). The Rappahannock River is a part of the Chesapeake Bay watershed and flows directly into the bay. The FOR has secured three years of funding through the National Oceanic and Atmospheric Administration (NOAA) to apply the Meaningful Watershed Educational Experience (MWEE). MWEEs have four essential components: Issue Definition, Outdoor Field Experiences, Synthesis and Conclusions, and Environmental Action Projects. The issue definition components include students learning about an issue as it relates to their community and their lives (NOAA Meaningful Watershed, 2022). The goal is to provide context about a larger picture environmental issue so that the students can connect it to their own lives and experiences. They should be able to explore driving and supporting questions about the issues defined and conduct research, talk to experts or people within the field, make observations, research credible sources, or make field observations

(National Oceanic and Atmospheric Administration, 2022). The environmental issue is preferred to be observable so their work applies to their own lives and they can find what they are learning in the accessible world around them. Along with the information conveyed in the issue definition essential of the MWEE, there is the hands-on learning with the outdoors essential. The outdoor field experiences work on getting the students involved with the local environment directly. They should be outside of the classroom setting and immersed in the local environment. It can include taking measurements or data using field technology or any other experiments. These experiences will add to the issue definition aspect of the MWEE to further connect them with the topic of environmentalism (NOAA Meaningful Watershed, 2022). They will see some of the environmental problems that are taught in the classroom or lesson section of education. By seeing the environmental problems in the community or environment surrounding the place they live there will be a deeper understanding of the environment and how it directly impacts them. The synthesis and conclusion happen throughout the MWEE experience and work on the sharing of claims and conclusions with other students (NOAA Meaningful Watershed, 2022). This is an aspect of the MWEE that is continuously worked on throughout the issue definition and outdoor experiences aspect of the MWEE. Synthesizing the information provided to them and relating it to their lives as well as the group activities will fulfill this aspect of the MWEE. Conclusions will be drawn throughout based on the combining of in and out-of-classroom experiences to relate their experiences with the community, surrounding environment, and their influence on the planet. Finally, the environmental action project essential in practice is a solution to a local environmental problem identified and solved by the students. This will be a way for the student to apply what the students learned from all of the topics that they during the in and out-of-school experiences. They will be able to look into the surrounding community and determine an environmental problem that needs to be solved and work towards developing a plan to solve it. As children, they may not be able to run for office or change laws but the feeling of competency in achieving a small task will help them connect to the community and environment around them. The competency will help the students understand that they do have a say in the world around them. That their actions do have impacts and they can choose environmental attitudes and beliefs that will change the world around them. Instead of leaving the students with the doom and gloom of environmental education they will feel empowered through the feeling of connecting with their community and making a difference.

The way I was involved with the Friends of the Rappahannock was in the outdoor experiences MWEE essential along with the community outreach. I helped them design educational materials for connecting the students to the local environment and community. The teachers at the local schools will be helping with the in-school learning and I focused on connecting the students to the Rappahannock river and the community around it through the hands-on activities I designed to be the bridge between in-school learning and out-of-school outdoor experiences. The lessons were created with the intention that they will be immersed in the environment while learning so they can further connect with the Rappahannock River.

Educational Materials for FOR

With the MWEE and the FOR, I aided in the outdoor field experiences and the environmental action project aspect. For the outdoor field experiences, the goal is to prepare the students for a paddling trip at the end of the school year or the end of the program. The considerations for outdoor experiences before the end-of-program paddling trip includes safety education, the ecological interactions surrounding the river, Leave-No-Trace principles, as well as team-building activities woven into the other educational experiences. Safety education would include different safety considerations for the river such as how to go through strainers, different parts of the river, and paddling safety. Safety education is important to include so that the students can better navigate the local environment and experience recreational and other experiences safely. Combined with the safety education would be education on the ecology of the river. This would include teaching about the potential flora and fauna found in the river, how the different parts of the river create different habitats, and identifying different human impacts on the river. Ideally, this would be through multiple outdoor experiences and each experience would build up to the paddling excursion. Each trip would need to have multiple learning styles available for different types of learning styles as well as centering the children's lives and experiences. The learning shouldn't only be related to entirely traditional science education models. The effect on connection to the environment is the same for both types of education, traditional scientific as well as a more artistic approach (Staples, 2019). One of the ways that art can help is by helping with observation-based learning as well as helping connect further by having different methods of learning (Hu, 2022). The outdoor learning experience will be one of the main ways that the students will connect with the community and the land around them through classroom-learned materials. The last way that they will feel connected to their

community is through environmental action projects. The inspiration for the way the environmental action plans should be structured is a program from San Francisco, California. The Kids for the Bay program always includes a project that the kids work on to help connect with the bay as well as the community around them. Their projects ranged from murals of creatures in the bay to designing warning signs for areas that drain into the bay, or trash cleanups (Mark, 2008). The projects will be similar in that they will be a classwide project (or student/small group) where the students determine a problem in their local environment and devise a solution. With the two experiences of outdoor learning experiences and environmental action projects combined, the goal of connecting students to the local community and the environment will be met. Overall, my project will help the Friends of the Rappahannock satisfy certain requirements within the Meaningful Watershed Education Experience. Within the MWEE requirements, I aided in meeting the outdoor experiences and community outreach requirements. I met these requirements by helping create a curriculum that will focus on place-based education and center the children's lives and community.

Activity Structure

Activities are planned with the intention of allowing multiple avenues of lessons. I am reflecting on the lessons that I have used in the past and a system that worked really well for me in the past. Each activity will have a section of background information with some of the key points that the instructors should focus on. The background information will help instructors determine the best plans for facilitating a lesson while also allowing the instructors to add their own passions. One of the best things about environmental educators is the passion behind the way information is taught and presented. Having activity and lesson plans that are loosely structured allows future educators to add their preferred method of presenting the information. There is a sample outdoor activity plan along with a set of discussion questions but there are multiple different lesson plans that could result from the activities given. The lesson plans can be paired with different activities so that they can build off of each other. For example, the macroinvertebrates lesson plan can be paired with the river structure lesson plan to help facilitate discussions about where the best location for sampling is. There will also be handouts that are either from other sources, such as a dichotomous key, or images created by myself to pair well with the information provided. The macroinvertebrate activity (see Appendix I) was included

because macroinvertebrates are indicator species through intolerance to certain pollutants and it is an easy tie-in to the impacts that humans have on the environment. This can also tie into food ecosystems, river structure, and water chemistry. For the history of land and the formation of rivers (see Appendix II) I included it so that the students can have something to connect with whenever they are looking at the Rappahannock. It will also help the students understand more information on how land use can impact rivers. I chose to include the Rappahannock River (see Appendix III) lesson to attempt to utilize the connection to a local waterway. This is utilizing place-based education because it is something that all of the kids can relate to through prior experiences or look forward to relating to in future endeavors. They will feel connected to the community and surrounding natural world because it is a river that they can identify themselves with and look to in the future. For the Otters in the Rappahannock activity (see Appendix IV) I wanted to include a lesson on river otters because they have recently returned to the Rappahannock river! It will be a fun way to connect with the art sculptures that were just put up around the town. It is also an animal that is very popular and can spark future interest in river ecosystems so students will hopefully continue to seek out information about the river. There is also going to be a larger effort to conserve otters and protect their habitat because it is something that they connect to through nature and community. The Leave No Trace activity (see Appendix V) is included because it is a widely known set of principles that cover a large number of considerations on how to ethically exist in the outdoors. If they can remember the principles of LNT then they are in good shape for considering their impact on the environment and feel confident in their ability to connect with the outdoors. The Nature Journaling activity (see Appendix VI) is included because I wanted to include a lesson that is more focused on another method of learning and connecting: Art. I think it is important to understand that not every student will identify with STEM-based activities or lessons. To maximize the potential of connecting to the world around there should be an addition of artistic activities. Since the Rappahannock river is the focus of the educational experiences it should include a lesson that features a Rappahannock river food chain (see Appendix VII). There is a lot of background information on what a food chain/web is and some terms associated with it. The best part about food chains/webs is that with the background knowledge the students can create them with organisms they have personally learned about.

Conclusion

I remember growing up in my hometown and experiencing an informal method of learning that remains with me to this day. My 7th-grade teacher brought in aquatic plants from an organization working towards the restoration of the Chesapeake Bay. I remember looking at the plants grow and I learned about how they were going to be relocated to the bay. They would slowly reverse the severity of the dead zones. Thinking back to that moment and what I am doing now it is clear that the moment had an impact on me. I went home and researched the Chesapeake Bay and the dead zones' impact on the plants and animals in it. I learned more and more about how it was caused by humans and it sparked my interest in the field of environmental science. My hope for starting this project was to provide an avenue for children to have these kinds of connections and something to look back on as they start their careers in environmental science. Studies have proven that connections to the environment during childhood are a precursor to environmental care as an adult (Gratton et al., 2004; Chawla & Cushing, 2007; Otto, 2017; Cheeseman, 2018). In my comprehensive research on the topic of environmental education, I found that the way environmental attitudes persisted past the day the information was presented. When the information is presented through informal education they will also find a stronger connection to their personal lives (Medrich et al., 1982; Coll, 2019). In working with the Friends of the Rappahannock I was able to provide activities that helped satisfy two essentials of the Meaningful Watershed Educational Experiences. From the activities, there will be an opportunity to spark lifelong connections to the world around us. The world around us will need more people who care about the world and will want to do something about it. Due to the connection that I felt in informal environmental education, I am entering the field of environmental education. Looking at the students as my teachers once did all those years ago.

Appendix I : Macroinvertebrates

Objectives: Students should be able to

- Understand what a macroinvertebrate is and how important they are for the ecosystem
- Differentiate between a pollution-tolerant species and a pollution-intolerant species
- Describe the relationship between macroinvertebrates and water quality

Background Information

Macroinvertebrates are incredibly important for an ecosystem's health for many reasons. They are important food sources for animals such as fish or larger insects. Certain macroinvertebrates require healthy stream quality so they can also tell the stream health based on which species are found. There are many different types of macroinvertebrates but we can start by breaking down the word. The word can be broken down into Macro and Invertebrates. Macro means that it is something that you can see with your eyes only. You do not need a microscope to see them. An Invertebrate is the opposite of a vertebrate (what we are!). Invertebrates are organisms without a backbone¹. Putting the two words together means that macroinvertebrates are organisms that do not have a backbone that we can see with our eyes. Macros can sometimes live in fast-moving streams where they are able to feed off of the food flowing past them. They would eat organic matter, leaves, or other plants that fall into the stream¹. Others are considered scrapers where they are in slower-moving pools of water and eat the algae off of the underwater surfaces¹.

There are three types of macroinvertebrates when it comes to how they handle stream quality. Some macros are tolerant species where they can live in a large range of habitat conditions and they are not sensitive to pollution. These will be able to tolerate poor conditions as well as healthy stream conditions². These species can handle changes in the ecosystem because their range of comfortable habitats is large enough that they will survive longer. Some species may be slightly sensitive to pollution where they may not have a large range of water quality they can handle but they can handle some disturbance. Intolerant (or indicator species) are macroinvertebrate species that can only live in specific stream conditions². They are sensitive to pollution and cannot handle a large range of ecosystems. Typically they require very healthy streams and cannot tolerate too much change to an ecosystem. They are typically excellent to find in streams because they indicate healthy stream conditions.

When a sample of a stream's macroinvertebrate population is collected you can look at the different species present along with the number of each species to determine the stream's health. If there are a lot of Mayflies, Stoneflies, or Water Pennies then that means that the stream has a lot of dissolved oxygen and is a healthy stream because they are pollution intolerant². A macro sample with many flatworms or midges and nothing else will show that the water quality is poor because they are not sensitive to pollution².

Outdoors activity

Lesson Plans can be scaled to different age groups

For older age groups (10+) use the river structure lesson to have them determine where the best place to find macroinvertebrates and have them sample at that location. Have students compare the different sampling sites and see what differences there may be between the sites as well as the testing methods

For younger students (under 10) you can tell them which areas have more nutrients and dissolved oxygen and lead them to the areas.

Materials Needed

Kicknet and/or D nets

Shallow white container for putting samples in

Tweezers

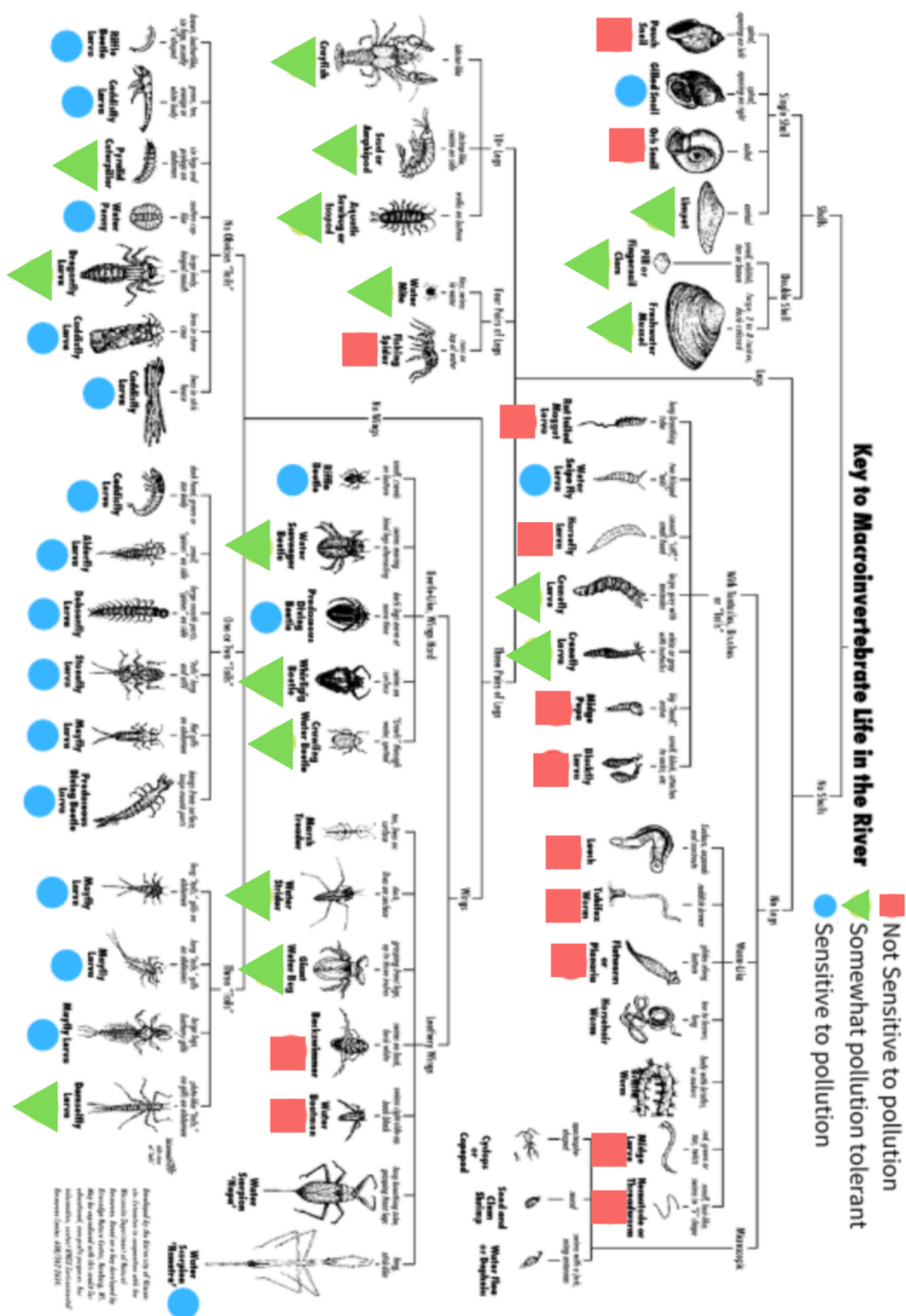
ID charts (dichotomous keys)

- Take the children to a stream and allow them to pick the place where they think that macroinvertebrates will like the most. Allow the groups to pick whichever place they want.
- Have the children sample the sites that they chose with the kick net or D-net, ensuring they are holding it at the correct angle (low to the water but not enough above the water and teaching them how to put rocks on the bottom net
- After they are done sampling the site, have them use the folding method where they fold it in half and pull up the sides so their sample isn't lost
- Lay the nets on the ground and use tweezers to pick out all of the macroinvertebrates and place them in a secondary container (preferably white or clear with about an inch of water in it)

- Walk them through the dichotomous key so they can attempt to identify the macros they find on their own
- Have the groups rotate to other group's samples and allow them to compare the sample sites each group chose
- If time is allotted then have them switch sites/choose another site based on the information gathered

Potential Discussion Questions

- 1) Which sampling site had the most number of macroinvertebrates found?
- 2) Are there any environmental conditions/disturbances nearby that may explain the results? (such as a large agricultural field or a large roadway)
- 3) Which sampling site had the most tolerant species? The most intolerant species?
- 4) What might the number of intolerant species mean for stream health?
- 5) What are some things that we can do that will help increase the health of the stream?
- 6) What can we do to help keep the stream healthy for the macroinvertebrates?



Continuing Education:

<https://www.macroinvertebrates.org/> → High-quality images of all macroinvertebrate families along with some additional information and resources

<https://www.sjrwmmd.com/education/macroinvertebrates/#:~:text=Macroinvertebrates%20are%20often%20called%20macros,many%20different%20types%20of%20macros> →

Drawing sheets for macroinvertebrates that include a section on background information

<https://extension.usu.edu/waterquality/macrokey/> → online version of the dichotomous key

<https://sites.allegheny.edu/creekconnections/aquatic-macroinvertebrate-fact-sheets/> → fact sheets for macroinvertebrates including information such as habitat, life cycle, and body morphology

<https://sites.allegheny.edu/creekconnections/classroom-resources/> → classroom resources ranging from

<https://hamiltonharbour.ca/resources/documents/Macroinvertebrates.pdf> → information on life cycles, anatomy, and classification

Works Cited

Extension Utah state university. (n.d.). *Water quality: Aquatic macroinvertebrates*. Utah state university. <https://rb.gy/ugav0i>

Metzger, L. (n.d.). *What insects tell us about water quality*. Ausable river association. <https://rb.gy/b22x78>

St. john's river water management district. (n.d.). *Education*. St. johns river. <https://rb.gy/eknqxj>

Appendix II : Formation of Rivers

Objectives: Students should be able to

- Understand how rivers are formed and what that means for the land around the river
- Recognize how land use impacts the river and its shape
- Identify some land features/vocab terms of a river

Along with how land use, and consequently human activity, can sometimes impact more than just pollution of the streams. They should be able to recognize some of the river features and understand what its purpose is.

Background Information

Rivers are formed through the water following the path of least resistance after falling from the atmosphere as rain draining in a watershed or coming up from the groundwater. A watershed is an area that flows to a specific waterway. For example; the Chesapeake Bay watershed includes all of the rivers, streams, and headwaters that drain into the bay along with the land that drains into these streams and rivers. The beginning of a stream is called the headwaters. This water is typically very cold and has a small trickle of water. On the east coast, streams are typically year-round while on the west coast and middle of the country are seasonal and depend on the snowmelt from the winter season⁴. The headwaters combined with the water draining from the ground around it forms a stream and as it travels through the path of least resistance, it will get larger because of the greater amount of surface water draining into the waterway along with other streams joining the other stream. When a stream joins another stream it is considered a tributary⁴. Streams will flow through the land gradually collecting more water and eventually the stream will become large enough to be considered a river. The river continues to flow and collect more surface water growing larger and larger until it meets a larger body of water like a bay! The section of the river that connects with a bay, lake, or ocean is considered the mouth of the river⁴. The bay will then flow into one of the oceans that cover most of the planet where the water will eventually evaporate and form water vapor which forms clouds. These clouds will then release their water on land again to start the cycle all over again⁴.

From this flow of water, the landscape is changed around rivers. Rivers are how canyons are formed and there are other cool effects on the land due to the flow of water⁴. The river's current can be strong enough to weather boulders into pebbles after a very long time. Rivers and

streams will cut into the surrounding soil and land (called the bank of the river) and it will carry these materials, called sediments) down the river. The plants and trees that line the river bank are called the riparian zone. If a bank has a lot of trees and plants in the riparian zone it will decrease the amount of erosion from the water's current². When there are a lot of rocks in a shallow section of the river it is called a riffle or rapid. The water flows through the exposed rocks and it creates a large amount of dissolved oxygen (DO) which is required for all of the organisms that breathe water under the surface⁴! Deeper sections of the river are called a pool and it typically has a slower current and more places for sediments to settle and deposit⁴.

All of these come together to form the rivers that we see today! The way that the water flows through the land has taken thousands of years to get that way. This is why it is very important we try to leave rivers the way that they are. Some ways that humans impact streams and rivers are through dams and channelization. Dams are when people put up a barrier to make the river flow through that make produce power or provide a large body of blocked water (a reservoir). This will change the river flow downstream from the dam and alter the organisms that live in the body of water. Channelization is when a river structure is changed to form a straighter, deeper, and potentially wider channel¹. This forever alters the organisms that live in the rivers that are channelized. The landscape surrounding a river is also altered and it may increase flooding because of the lack of a riparian zone and the banks will erode away. There is also a lack of depositing sediments because of the change in flow¹.

Outdoor Activity

This lesson can be taught at a stream or river site so that the children can seek out the specific structures talked about during the lesson. A stream walk-through talking about the different structures would be a good way to incorporate movement and sight recognition. This can also precursor the lesson on macroinvertebrates so that they can connect the macroinvertebrates to certain sections of the river and a deeper discussion on the food chain can happen. There are also a couple of diagrams with the terms labeled on the rivers with one of them having additional labeling for point and non-point pollution sources.



Point or non-point source

Key

Point: C, E

Non-Point: A, B, D

Continuing Education

<https://www.twinkl.com/teaching-wiki/river> → This is very long and filled with a lot of terms and definitions but it does include a lot of information in it.

<https://www.sciencebuddies.org/stem-activities/build-river-model> → Craft/experiment to build your own river model.

<https://www.fisheries.noaa.gov/national/habitat-conservation/river-habitat> → NOAA webpage on river habitats while tying in some conservation efforts.

Works Cited

Brooker, M.P. (1985). The ecological effects of channelization. *The geographical journal*, 151(1), 63-69. <https://doi.org/10.2307/633280>

Extension Utah state university. (n.d.). *Riparian zones*. Utah state university. <https://rb.gy/g9lzgn>

Rutledge, K., McDaniel, M., Teng, S., Hall, H., Ramroop, T., Sprout, E., Hunt, J., Boudreau, D., & Costa, H. (2022, May 20). *Understanding rivers*. National Geographic. <https://rb.gy/ujqqq8>

Appendix III: Rappahannock River

Objectives - Students will be able to:

- Learn about land use in the Rappahannock river
- Connect with a local waterway
- Know more about the Rappahannock River history
- Understand threats to the river and the Chesapeake Bay

The river that flows next to Fredericksburg is called the Rappahannock River and a fun fact is that it is the longest free-flowing river in the east⁵! There used to be a dam of the river called the Embrey Dam but it was removed in 2004 and this allowed the river to flow freely through Virginia all the way to the Chesapeake Bay⁵. The land that drains into the Rappahannock River is called the watershed and it includes a large percentage of agricultural land. The land use statistics show that there has been an increase in developed land in the watershed. In 1985 the urban and suburban land was at 89,000 acres while in 2019 there were over 166,000 acres of developed land (an increase of 87%)². The percentage of land that is agricultural is at about 12% in 2019 and there is a commitment to keeping that number about the same to reduce agricultural runoff. Looking at a map of development in the watershed a large portion of the developed land is in and around the city of Fredericksburg². Each type of land use has its own dangers for the water and the river.

Suburban and urban areas have a large risk of adding human-made pollutants to the ecosystems. Items such as plastics, oils, litter, and other man-made pollutants enter the water from rainwater runoff⁴. In areas that are developed, there are more impervious surfaces meaning water does not seep into the soil as much and collects pollution as it flows over the manmade surfaces. There is also the removal of riparian buffers that help filter out pollutants when water enters a river through runoff⁵.

For agricultural land development, there are different types of pollutants. When fertilizer is applied to the farms the excess enters the stream as runoff. Fertilizers have nutrients that help plants grow called phosphorus and nitrogen and when they enter streams they accelerate aquatic plant growth². When the aquatic plants take over the space they crowd out other organisms and block out the sunlight. When the space gets too crowded they die off and the process of decomposition takes away available oxygen for other living organisms. This causes a dead zone where nothing can live because of the conditions³. This is what occurs in the Chesapeake Bay

because of the amount of agricultural land that is in the watershed³. Another problem that arises from agricultural development is that natural plant life is cleared out for farming and there is a loss of soil, diversity in plant species, and riparian buffers in some cases. This is more applicable to larger industrial farming because local farmers are more sustainable and have better agricultural practices. Although there are varying degrees of impacts on the environment based on the type of land use surrounding the river, each impacts the river.

There are two types of pollutants relating to how easy it is to trace the pollutant. Point source pollution is pollutants that you can trace back to a single, identifiable source (you can *point* to the source)¹. Examples of these would be a pipe or an oil spill from a ship. Non-point pollution is also called diffused pollution because it is over a larger area and is not as easy to tell the exact source. An example of this would be land use and agriculture¹.

Continuing Education

<https://oceanservice.noaa.gov/facts/eutrophication.html> → NOAA video and information on Eutrophication

<https://www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution> → EPA webpage on point and non-point pollution along with factsheets both current and historical.

<https://www.fs.usda.gov/nac/practices/riparian-forest-buffers.php#:~:text=A%20riparian%20forest%20buffer%20is,primarily%20to%20provide%20conservation%20benefits.> → USDA webpage on riparian buffers

Works Cited

- Environmental Protection Authority Victoria. (2021, August 25). Point and non-point sources of water pollution. <https://rb.gy/ivomis>
- Integrated Trends Analysis Team. (2021). *Rappahannock tributary summary: A summary of trends in tidal water quality and associated factors, 1985-2018*. Chesapeake Bay Program. <https://rb.gy/ksqu00>
- Chesapeake Bay Foundation. (n.d.). *Nitrogen & Phosphorus*. Chesapeake Bay Foundation. <https://rb.gy/r0bh0y>
- Chesapeake Bay Foundation. (n.d.). *Runoff pollution*. Chesapeake Bay Foundation. <https://rb.gy/0kroe9>
- Roberts, Allen D. (2010). Effects of urban and non-urban land cover on nitrogen and phosphorus runoff to Chesapeake Bay. *Ecological Indicators*. 10(2), p. 459-474.
<https://doi.org/10.1016/j.ecolind.2009.07.017>
- Thomas-Blate, J. (2018). *A legacy of river protection and restoration in the rappahannock*. American Rivers. <https://rb.gy/4cch4h>

Appendix IV: River Otters in the Rappahannock

Objectives -Students will be able to:

- Understand the difference between river otters and sea otters' characteristics and distribution
- Know which habitats river otters prefer
- Know the different adaptations that river otters have for their habitat
- Understand the river otters' place in a food chain

Background Information

There are two species of otters in the United States (and 13 worldwide!) the North American River Otter (*Lontra canadensis*)⁵ and the Sea Otter (*Enhydra lutris*)⁴. The Sea Otter lives off the West Coast including Alaska while the North American River Otter lives across the East Coast, the Pacific Northwest, Alaska, and even into Canada. The river otter's habitat mainly depends on permanent sources of water but they can live in diverse ranges of habitats ranging from swamps to rivers and lakes. They create dens in burrows, vegetation, or rocks on the riversides close to the water^{2,5}. They will sometimes even use muskrat/beaver lodges. While the river otters typically live alone in their dens they are social animals and enjoy playing with other river otters along with socializing and strengthening their social bonds/hunting skills⁵. They can also grow to three or four feet long and eat a variety of different riverside organisms⁶. They have a very high metabolism because of how active they are so they need to consume a lot of energy. They can eat organisms like fish, crayfish, frogs, bird's eggs, and turtles along with aquatic plants sometimes⁶. They communicate with other otters through whistles, yelps, screams, and growls along with a musky scent marker from the base of their tails⁶. A fun fact about their tail is that they comprise over 40% of their total body length and they can swim up to 8 miles per hour⁵. Their webbed feet are made to help propel and paddle through the water. Their feet also have claws so that they can grab their prey⁵. Their eyes are also adapted to living in the water. They are located near the top of their head for surface swimming and they have a third eyelid for protection underneath the water's surface⁵. They can even navigate cloudy/dark water due to their whiskers! Their whiskers are sensitive enough to catch food in water that they cannot see in⁵.

River otters like to live in unpolluted water that isn't excessively disturbed by humans. Water pollution is one of the ways that otters can lose their habitat. There is also habitat loss through land use changes like development and damming of the river. Pollution can impact their food sources and cause them to move to a different location than what they are originally from⁵. If the pollution impacts the fish or other wildlife in the river that the otters depend on for food then they will not be able to maintain the energy needed to thrive. Though they are not listed as endangered nationally... it is still important to consider our impact on their habitat and existence⁶. They only recently returned to the Rappahannock river so we should work to make sure they can stay in the area!

Hands-on Learning

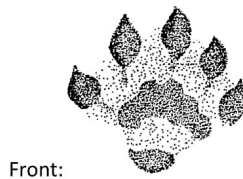
One of the ways that could serve as a way to include hands-on learning is to get (man-made if possible or ethically sourced) otter pelt and allow the children to feel the fur. There are also feet molds that can be passed around where they can point out different things that they notice about them and guess how they help the otter survive in their habitat. These can be supplemented with handouts as well but tangible items always pique curiosity more. Seeing an otter in the wild is difficult because we don't want to disturb their potential den or living space but having them point out good locations for otter dens can help them apply what they are learning to an outdoors component (emphasize LNT principles!)

Potential Discussion Questions

1. Why are otters important for the ecosystem?
2. What are some things that are important for an otter's habitat?
3. How do adaptations help otters live in their habitat?
4. What would happen to the otters if pollution killed off the macroinvertebrates (fish and crawfish's food source)?
5. How might stream channelizing impact the otters?

Hand Outs

River Otter Tracks³



Front:
Length - $3\frac{3}{4}$ "
Width - $3\frac{3}{4}$ "



Hind:
Length - $3\frac{3}{4}$ "
Width - $3\frac{3}{4}$ "



River otter track pattern

Otter Den Example²



Continuing Education

<https://www.nationalgeographic.com/animals/mammals/facts/north-american-river-otter> →

National Geographic webpage on the northern river otter

<https://www.inaturalist.org/taxa/41777-Lontra-canadensis> → iNaturalist page on the North American River Otter that has a lot of information on stuff like habitat, taxonomy, and similar species. Inaturalist will also show pooled data where people on the website have found them.

Works Cited

Animalia. (n.d.). *North american river otter*. Animalia. <https://rb.gy/aihrbc>

BiodiversityWorks. (n.d.). Coastal River Otter Natural History. BiodiversityWorks.

<https://rb.gy/zlisp>

Goodman, D., & Kem, T. (n.d.). River Otter Tracks. Illinois Department of Natural Resources.
<https://rb.gy/7xb6x>

Montrey Bay Aquarium. (n.d.) *Sea otter*. Monterey Bay Aquarium. <https://rb.gy/feb3ch>

Smithsonian National Zoo & Conservation Biology Institute. (n.d.). *North american river otter*.

Smithsonian. <https://rb.gy/xbxnhk>

The National Wildlife Federation. (n.d.). *North american river otter*. NFW. <https://rb.gy/fbxumy>

Appendix V : Leave No Trace (LNT)

Objectives- Students should be able to:

- Learn the principles of Leave No Trace
- Understand ways that the environment is impacted through human recreation
- Have a fun hand sign method to remember the principles of Leave No Trace

One of the important things when enjoying the outdoors is preservation for other people who want to enjoy the outdoors. A well-respected set of principles that have developed over time are the seven principles of Leave No Trace (LNT). They are principles because they are not rules necessarily but a way of thinking in the outdoors that limits your impact without compromising your safety. This is why they are not rules because personal safety is always incredibly important when in the outdoors. The principles can be found on the official National Park System Website and they are as follows:

1. Plan Ahead and Prepare¹
 - a. Know the regulations and special concerns for the area you'll visit.¹
 - b. Prepare for extreme weather, hazards, and emergencies.¹
 - c. Schedule your trip to avoid times of high use.¹
 - d. Visit in small groups when possible. Consider splitting larger groups into smaller groups.¹
 - e. Repackage food to minimize waste.¹
 - f. Use a map and compass or GPS to eliminate the use of marking paint, rock cairns, or flagging.¹
2. Travel and Camp on Durable Surfaces¹
 - a. Durable surfaces include maintained trails and designated campsites, rock, gravel, sand, dry grasses, or snow.¹
 - b. Protect riparian areas by camping at least 200 feet from lakes and streams.¹
 - c. Good campsites are found, not made. Altering a site is not necessary.¹
 - d. In popular areas:
 - i. Concentrate use on existing trails and campsites.¹
 - ii. Walk single file in the middle of the trail, even when wet or muddy.¹

- iii. Keep campsites small. Focus activity in areas where vegetation is absent.¹
- e. In pristine areas:
 - i. Disperse use to prevent the creation of campsites and trails.¹
 - ii. Avoid places where impacts are just beginning.¹
- 3. Dispose of Waste Properly¹
 - a. Pack it in, pack it out. Inspect your campsite, food preparation areas, and rest¹ areas for trash or spilled foods. Pack out all trash, leftover food, and litter.¹
 - b. Utilize toilet facilities whenever possible. Otherwise, deposit solid human waste in catholes dug 6 to 8 inches deep, at least 200 feet from water, camp, and trails. Cover and disguise the cathole when finished.¹
 - c. Pack out toilet paper and hygiene products.¹
 - d. To wash yourself or your dishes, carry water 200 feet away from streams or lakes and use small amounts of biodegradable soap. Scatter strained dishwater.¹
- 4. Leave What You Find¹
 - a. Preserve the past: examine, photograph, but do not touch cultural or historic structures and artifacts.¹
 - b. Leave rocks, plants, and other natural objects as you find them.¹
 - c. Avoid introducing or transporting non-native species.¹
 - d. Do not build structures, furniture, or dig trenches.¹
- 5. Minimize Campfire Impacts¹
 - a. Campfires can cause lasting impacts to the environment. Use a lightweight stove for cooking and enjoy a candle lantern for light.¹
 - b. Where fires are permitted, use established fire rings, fire pans, or mound fires.¹
 - c. Keep fires small. Only use down and dead wood from the ground that can be broken by hand.¹
 - d. Burn all wood and coals to ash, put out campfires completely, then scatter cool ashes.¹
- 6. Respect Wildlife¹
 - a. Observe wildlife from a distance. Do not follow or approach them.¹

- b. Never feed animals. Feeding wildlife damages their health, alters natural behaviors, [habituates them to humans], and exposes them to predators and other dangers.¹
 - c. Protect wildlife and your food by storing rations and trash securely.¹
 - d. Control pets at all times, or leave them at home.¹
 - e. Avoid wildlife during sensitive times: mating, nesting, raising young, or winter.¹
7. Be Considerate of Other Visitors¹
- a. Respect other visitors and protect the quality of their experience.¹
 - b. Be courteous. Yield to other users on the trail.¹
 - c. Step to the downhill side of the trail when encountering pack stock.¹
 - d. Take breaks and camp away from trails and other visitors.¹
 - e. Let nature's sounds prevail. Avoid loud voices and noises.¹

Following these principles will ensure that you are always being considerate of the plants, animals, and humans around you for the current generation and those to come!

Hands-On Activity

There is a fun set of hand signs that are attached to each principle and they help remember the number along with the principle associated with it. I could not find a video already made of the set that I prefer so I made this video to better reflect what I have learned. This would be a way to add physical motion to the lesson. Another way that I have utilized this in the past is through a jeopardy game that has questions from each principal so that is another option for a hands-on activity! This is a link to the google drive-I am not sure how to better upload this.

https://drive.google.com/file/d/1jv-htZZs_uwl1Hv3jj77m28aHBgMa-O_/view?usp=share_link¹

Continuing Education

<https://Int.org/> → Leave No Trace website where information can be found on the history, ways to get involved, and some of the actions that they do.

<https://www.rei.com/learn/expert-advice/leave-no-trace.html> → REI website article on Leave No Trace-including a video

Works Cited

National Park Service. (2022, Jun 16). Leave no trace seven principles. NPS.
<https://rb.gy/8o8u0c>

Appendix VI: Nature Journaling Activity

Objectives - Students will be able to:

- Learn a separate method of connecting with the environment
- Spend less restricted time in the outdoors
- Connect their own interests, experiences, and talents with the world around them

Background Information

Not every student is going to connect with the environment through a STEM-based lesson or activity. There are a lot of children who may relate and connect more through art and how it helps them see the world around them. One of the ways to include these artistically inclined students is to build in a variety of activities that do not only focus on STEM-based activities. A great way to include art in the natural world is a nature journal relating to their personal experiences and interests.

Each student can be given (or they can make!) their own journal to bring on all of the outdoor visits/experiences. At the end of each lesson, there can be a question that focuses on how they would like to learn or relate to the world around them. From a nature journal, they get to choose what they would like to write or draw about. Some questions to ask them to draw/write about include focusing on things that piqued their interest, how they felt, and something they can bring in from their personal lives and experiences. They should be given time to sit and find the thing that they would like to draw or write about.

Discussion Questions

1. Draw or write about something you learned about today that you found exciting or interesting to learn about.
2. Draw or write about something that you would like to learn about.
3. Draw or write about how you felt during the lesson.
4. Draw or write about a memory you have from another time you interacted with something you saw today.
5. Draw or write about a story including some of the things you can see around you or something you learned about today.

Continuing Education

<https://johnmuirlaws.com/journaling-curriculum/> → Additional information on Nature Journaling along with some resources like a video, facebook, and lesson plans

<https://www.lilyandthistle.com/how-to-start-a-nature-journal-today/> → a “how to” webpage on starting a nature journal

<https://christineelder.com/nature-journaling-kids/> → Benefits of nature journaling

Appendix VII: Rappahannock River Food Chain

Objectives - Students will be able to:

- Understand what an autotroph and a heterotroph is and know the difference between them
- Describe what a producer, herbivore, omnivore, carnivore, and detritivore/decomposer is
- Familiarize themselves with the concept of energy movement in a food chain/web
- Build a food web/chain using organisms they know both in the Rappahannock river and be able to translate to other habitats
- Understand how important every single organism is for the ecosystem

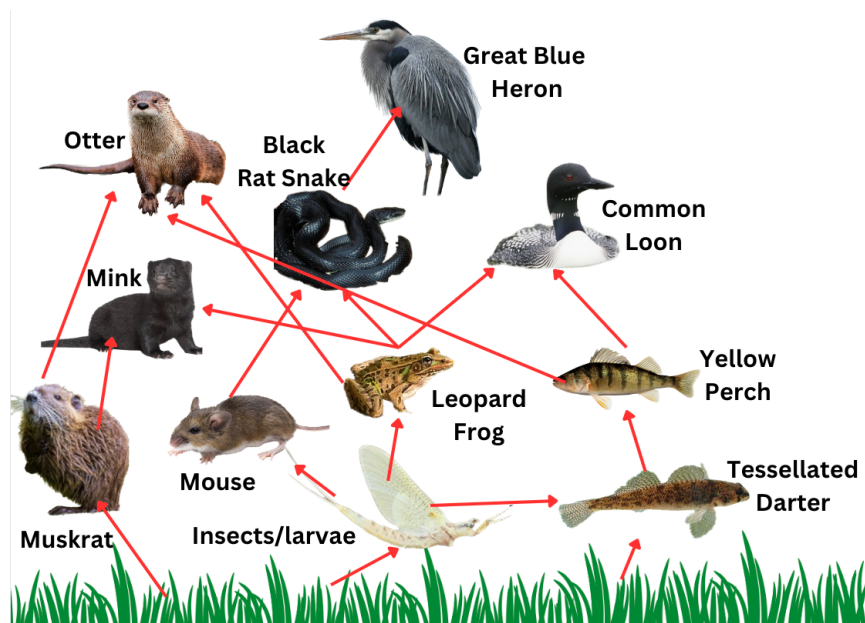
Background Information

One of the important things to understand about the environment is how interconnected everything is. One of the ways to represent this is in a food chain or a food web. Both of these are visual representations of how energy moves in an ecosystem typically through consumption patterns. Organisms need energy to be able to move, reproduce, and fulfill their ecological niches. Food chains are simpler and represent one path of consumption and how energy moves in those few interacting organisms within an ecosystem. A food web represents more than one consumption path and is closer to representing how energy moves in an ecosystem but is more complex. Organisms in an environment can obtain energy a couple of different ways. Autotrophs are organisms that can produce their own energy while heterotrophs cannot produce their own energy and need to get their energy from another organism (typically through eating another organism). In a food web or chain, there are different levels of organisms called trophic levels. The first level is called producers and they are the autotrophs of an ecosystem because they produce energy typically through photosynthesis. Some examples of aquatic producers are plants and algae. The second level in a food web/chain is the consumers and they are further divided into primary, secondary, and tertiary consumers. Consumers eat other organisms to obtain energy so they are the heterotrophs of the ecosystem. Primary consumers are herbivores and eat the producers, secondary consumers eat the herbivores and are called carnivores, and tertiary consumers eat the secondary consumers. There may be more levels to this system until it reaches the top predator. Food webs are more complex because some organisms can be both secondary consumers and tertiary consumers. Omnivores are organisms that can eat both producers and consumers. The last two terms to describe organisms in a food chain is detritivores and decomposers. Detritivores will eat dead or decaying organisms, an example being vultures eating

roadkill. Decomposers are the organisms that recycle dead or decaying organisms into nutrients that complete the nutrient cycling in an environment because producers will use these to grow.

Any disruption in a food chain/web will cause the entire ecosystem to change because of the breaking of the chain/web. When one piece of the chain breaks then the entire link falls apart. Which is why it is important to try and care for every organism in the ecosystem from the macroinvertebrates to the Bald Eagles. It is important to ensure a healthy environment for the smaller organisms as well because of bioaccumulation. As you move up the food chain biomass decreases. Biomass is the energy in living organisms and there is always more biomass in the lower trophic levels (producers) compared to the tertiary consumers. The loss of biomass can be one of the disruptions that cause the ecosystem to tip out of balance. With bioaccumulation, there is an increase in harmful chemicals/pollutants as you move up the food chain. When pollutants enter an ecosystem they enter the tissues/settle on plants. Herbivores will eat the pollutants off of the herbivores throughout their lives and the pollutants will remain in the tissues. A secondary consumer will eat the primary consumers and the pollutants will then accumulate in their tissues. This means that with each increase in the trophic level, there will be more pollutants stored in tissues. This becomes an issue when the pollutant impacts the survival of organisms. This is why it is important to consider how we interact with the ecosystem and what we are putting into it.

Rappahannock River Food Web Example



The producers represented by the grass are algae and aquatic plants

Hands-on Activity

For teaching food chains there is an art project that helps visualize the importance of each species in the chain. The project includes physically making a paper chain with each chain representing a consumption link.

Materials Needed

Paper

Scissors

Coloring utensils

glue

Lesson

1. Have the group decide which food chain they would like to represent with the project
2. Cut out strips of paper about an inch wide and make them long enough that they can make a circle when overlapped.
3. Each paper will represent an organism in the food chain. They should have a producer, primary consumer, as well as secondary and tertiary consumer. You should also have them include a decomposer.
4. Each strip of paper that represents an organism will need to be made into a circle. Glue one end of the strip that represents the producer and fold it to the other side to make a circle. When adding the primary consumer put the paper through the circle and then glue it together to make a circle.
5. Keep adding the organisms in the same order of the food chain and this will create a physical chain of paper representing a food chain. If you included a decomposer you can make the chain a circle by putting the paper through the first producer and the last consumer to then make a circle (referring to how it cycles back nutrients)

Additional Human Impact Lesson

A way to add a lesson on human impacts is to teach them how everything is connected in a food chain. For this, you can tell them to come up with a human-caused environmental problem or give them a list of examples to choose from. You can ask them to think about how that problem would impact each of the organisms in the food chain and then have them guess which one they think would be impacted directly the most. When they decide you tell them to cut off

the organism and notice that it breaks the chain and then talk about how even one organism will tip the balance in an ecosystem.

This art activity was found at this website and it has a bunch of other art/online activities that talk about food chains/webs → <https://www.weareteachers.com/food-webs/>

Works Cited

National Geographic. (n.d.). *Food Web*. <https://rb.gy/gpfytf>

Food Chain Citations

Audubon. (n.d.). *Guide to north american birds: Common loon*. <https://rb.gy/fnhabz>

Chesapeake Bay Program. (n.d.). *American mink*. <https://rb.gy/j79fwx>

Chesapeake Bay Program. (n.d.). *Black rat snake*. <https://rb.gy/ciwnet>

Chesapeake Bay Foundation. *Fones cliffs fauna*. <https://rb.gy/5l0nam>

Chesapeake Bay Program. (n.d.). *Mayfly*. <https://rb.gy/zqqqwr>

Chesapeake Bay Program. (n.d.). *Muskrat*. <https://rb.gy/wgydno>

Chesapeake Bay Program. (n.d.). *River otter*. <https://rb.gy/oebtax>

Chesapeake Bay Program. (n.d.). *Smallmouth bass*. <https://rb.gy/yo24tx>

Chesapeake Bay Program. (n.d.). *Southern leopard frog*. <https://rb.gy/3iytlv>

Chesapeake Bay Program. (n.d.). *Tessellated darter*. <https://rb.gy/azdifg>

Chesapeake Bay Program. (n.d.). *Yellow perch*. <https://rb.gy/blqrfp>

McCauley, J. (2009). Rappahannock river valley national valley refuge: Comprehensive conservation plan December 2009. U.S. Fish and Wildlife Service. <https://rb.gy/3agbwa>

Virginia DWR. (n.d.). *Northern white-footed mouse*. <https://rb.gy/9gaamg>

Works Cited

- Acar, Habib. (2014). Learning Environments for Children in Outdoor Spaces. *Procedia - Social and Behavioral Sciences*. 141, p. 846-853. Retrieved from <https://doi.org/10.1016/j.sbspro.2014.05.147>.
- American Rivers. (n.d.) Rappahannock river: Fish on. Retrieved Sept 24th, 2022 from <https://www.americanrivers.org/river/rappahannock-river/>
- Bushnell, D. I. (1935). The manahoac tribes in virginia, 1608. *Smithsonian Miscellaneous Collections*, 94(8), 1-84. https://repository.si.edu/bitstream/handle/10088/24003/SMC_94_Bushnell_1935_8_1-56.pdf?sequence=1&isAllowed=y
- Chawla, L., & Cushing, D. F. (2007). Education for strategic environmental behavior. *Environmental Education Research*, 13(4), 437-452. <https://doi.org/10.1080/13504620701581539>
- Cheeseman, A., & Wright, T. (2018). Examining environmental learning experiences at an earth education summer camp. *Environmental Education Research*, 25(3), 375-387. <https://doi.org/10.1080/13504622.2018.1509301>
- Chesapeake Bay Program (n.d.) Learn the issues. Retrieved Sept 25th, 2022 from <https://www.chesapeakebay.net/issues>
- Coll, S. D., & Coll, R. K. (2019). *Enhancing science learning through learning experiences outside school (LEOS): How to learn better during visits to museums, science centers, and science fieldtrips*. BRILL. Retrieved From <https://ebookcentral.proquest.com/lib/allegHENY-ebooks/detail.action?docID=5906228>.
- Environmental protection agency. (2005, March). *Protecting water quality from agricultural runoff*. EPA. Retrieved from https://www.epa.gov/sites/default/files/2015-09/documents/ag_runoff_fact_sheet.pdf
- Friends of the Rappahannock. (n.d.) *Fracking*. Retrieved on March 24, 2023 from <https://riverfriends.org/fracking/>
- FXBG City of Fredericksburg. (n.d.) *History of fredericksburg*. Retrieved Sept 24th, 2022 from <https://www.fredericksburgva.gov/202/History-of-Fredericksburg>
- Galton, A., Sinclair, M., & Purnell, K. (2004). Changes in attitudes, beliefs and behaviour: A critical review of research into the impacts of environmental education initiatives. *Australian Journal of Environmental Education*, 20(2), 41-52. Retrieved from <https://www.jstor.org/stable/44656394>
- Gill, Tim. (2014). The benefits of children's engagement with nature: A systematic literature review. *Children, Youth, and Environments*, 24(2). <https://doi.org/10.7721/chilyoutenvi.24.2.0010>
- Hofstein, A., & Rosenfeld, S. (1996). Bridging the gap between formal and informal science learning. *Studies in Science Education*, 28(1), 87-112. DOI:10.1080/03057269608560085
- Hu, H. (2022). Rethinking nature journaling in the Kindergarten Program action research in learning and teaching. *Journal of Outdoor and Environmental Education* 25, 159–179. <https://doi.org/10.1007/s42322-022-00095-0>
- Irby, Suzanne. (2019, May 23). *Researchers aim to shed light on water quality impacts of a growing fredericksburg region*. Virginia Tech. <https://vtx.vt.edu/articles/2019/05/ext-fredericksburgwater.html>
- Jones, J. W. (2015). Freshwater mussels of virginia (bivalvia: Unionidae): An introduction to their life history, status and conservation. *Virginia Journal of Science*, 66(3), 309-331.

- https://www.mussellab.fishwild.vt.edu/mussel/PDFfiles/2015/Jones_2015_Virginia_J_Science.pdf
- Mark, J. (2008). Kids for the bay. *Earth Island Journal*, 22(4), 19-20. Retrieved Sept 25th, 2022 from <https://www.jstor.org/stable/43879577>
- Mayer, S. & F., Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, 24(4), 503-515. <https://doi.org/10.1016/j.jenvp.2004.10.001>
- Mayer, S., & Frantz, C. M. (2008). Why is nature beneficial?: The role of connectedness to nature. *Environment and Behavior*, 41(5), 607–643. <https://doi.org/10.1177/0013916508319745>
- Medrich E. A., Roizen J., Rubin V., & Buckley S. (1982) *The serious business of growing up*. University of California Press, Berkeley
- Merriam-Webster. (2022). "Environment". Retrieved Sept 24th, 2022 from <https://www.merriam-webster.com/dictionary/environment#:~:text=1%20%3A%20the%20circumstances%2C%20objects%2C,determine%20its%20form%20and%20survival>
- Moore, C. & Forget, K. (n.d.). *Rebuilding virginia's oyster population through restoration and replenishment efforts: Our common agenda*. Friends of the Rappahannock. Retrieved from <https://riverfriends.org/rebuilding-virginias-oyster-population-through-restoration-and-replenishment-efforts-our-common-agenda/>
- National oceanic and atmospheric administration. (2022, August 9). MWEE essential elements. NOAA. Retrieved on March 24, 2023 <https://www.noaa.gov/education/explainers/noaa-meaningful-watershed-educational-experience>
- National oceanic and atmospheric administration. (2022). *NOAA meaningful watershed educational experience*. Retrieved Sept 24th, 2022 from <https://www.noaa.gov/sites/default/files/2022-09/NOAA-MWEE-definition-2022-08.pdf>
- National oceanic and atmospheric administration. (2023, January 12). *Blue crab*. NOAA Fisheries. Retrieved From <https://www.fisheries.noaa.gov/species/blue-crab>
- Native Land Digital. (2022, September 30). Whose Land. Retrieved Oct 22nd, 2022 from <https://native-land.ca/>
- Otto, S., & Pensini, P.(2017). Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behaviour. *Global Environmental Change*, 47, 88-94. <https://doi.org/10.1016/j.gloenvcha.2017.09.009>
- Phelps, A. (2019, May 3). *Native language: Reviving patawomeck*. UMW HISP Archaeology Laboratory. <https://umwarchaeologylab.com/class-projects/abigail-phelps-native-language-reviving-patawomeck/>
- Rountree, H. C. (1996). *Pocahontas's people : The powhatan indians of virginia through four centuries* (1st ed.). University of Oklahoma Press.
- Roberts, Allen D. (2010). Effects of urban and non-urban land cover on nitrogen and phosphorus runoff to Chesapeake Bay. *Ecological Indicators*. 10(2), p. 459-474. <https://doi.org/10.1016/j.ecolind.2009.07.017>

- Sellmann, D., & Bogner, F. X. (2013). Effects of a 1-day environmental education intervention on environmental attitudes and connectedness with nature. *European Journal of Psychology of Education*, 28(3), 1077-1086. <https://www.jstor.org/stable/23581537>
- Smithsonian Environmental Research Center. (n.d.) *Ictalurus furcatus*. Nemesis. Retrieved From [https://invasions.si.edu/nemesis/species_summary/163997#:~:text=Blue%20Catfish%20\(Ictalurus%20furcatus\)%20are,popular%20gamefish%20as%20a%20result](https://invasions.si.edu/nemesis/species_summary/163997#:~:text=Blue%20Catfish%20(Ictalurus%20furcatus)%20are,popular%20gamefish%20as%20a%20result)
- Staples, A. F., Larson, L. R., Worsley, T., Green, G. T., & Carroll, J. P. (2019). Effects of an art-based environmental education camp program on the environmental attitudes and awareness of diverse youth. *The Journal of Environmental Education*, 50(3), 208-222. <https://doi.org/10.1080/00958964.2019.1629382>
- Virginia Department of Wildlife Resources. (2023). *Northern river otter*. Virginia DWR. Retrieved from <https://dwr.virginia.gov/wildlife/information/northern-river-otter/>
- Wells, N. M., & Lekies, K. S. (2006). Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. *Children, Youth, and Environments*, 16(1), 1-24. <http://www.jstor.org/stable/10.7721/chilyoutenvi.16.1.0001>